Rover Technology for Mars Surface Exploration*

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Abstract Submitted to Second IAA International Conference on Low-Cost Planetary Missions

This paper provides an overview of emerging technologies in miniaturized roving vehicles that enable new types of low-cost planetary missions, those which are aimed at detailed survey of extended surface areas, collection and analysis of interesting samples, and in-situ analysis of scientific data. The paper shows how new types of planetary surface data can be acquired at low-cost through the use of innovative technologies embedded in lightweight autonomous vehicle systems.

The baseline system is the Sojourner rover that will be deployed by the Mars Pathfinder Mission lander to be launched in 1996, and which will land in July of 1997. This rover weighs about 15 kg, including mass added to the lander to support the rover deployment. 'l'his rover will perform experiments in instrument deployment and characterization of local surface terrain in the vicinity of the lander. Sojourner will be the first autonomous vehicle to ever rove on a planetary surface. The only prior rover missions occurred in the late 1960's and early 1970's and focused on Lunar explor at ion. .

One of the key challenges is how to acquire more and better Mars surface science, at a low overall mission cost. The paper discusses both of these goals, better science and lower cost, of Mars surface exploration missions.

Development of technology for the acquisition of more and better science from the Martian sur-face is a topic of great interest to the Mars scientific community, as reflected in the proceedings of several committees (e.g. Mars Science Working Group) which provide advice to various levels of NASA programs. An on-going dialog with this community reveals the following illustrative highlights and recommendations. l'here is a perceived need for exploration of relatively large areas. Technology development to accommodate a more precise landing (e.g. the Mars Pathfinder landing ellipse is approximately 150km). The interplay between technologies for landing ellipse reduction (by an order of magnitude) interplays with the requirement for rover traverse. The Mars geology community is seeking two orders of magnitude increase in the rover traverse capability relative to Sojourner (nominal mission is within 10's of meters from the lander). '1'here is also the desire for more on-board system autonomy, for example, the ability to search for rocks of particular characteristics. Survival for at least 3 months at relatively high latitudes (up to 60 degrees) is desired. in the long range mission horizon, is the desire to perform a low-cost sample-return-to-Iiarth mission. This goal involves the development of many technologies which affect the spacecraft and ascent vehicle, methods for propellant production, sample acquisition and packaging etc. On the other hand, these goals must be achieved at a low-cost, which implies the overall mass and volume must be low, and the rover must not add significant complexity to the overall mission.

Such challenging mission goals can only be met with the development of new and innovative technologies: 1) lightweight miniaturized vehicle designs with a high-degree of mobility and maneuverability while operating in rocky terrain beyond the line-of-sight of the lander; 2) survivability technologies in thermal control, low-temperature batteries, and

high-density low-temperature electronics to accommodate longer duration missions; 3) lightweight mechanisms and instruments for scientific sample acquisition and processing; 4) sensing and control systems to allow for precision landing; and 5) implementable systems for low-cost sample return. This paper summarizes the results of a technology development and terrestrial demonstration program, sponsored by the National Aeronautics and Space Administration Office of Space Access and "1'ethnology, that is currently evaluating these technologies in terrestrial laboratory and field experiments that accurately simulate the terrain and ambient conditions on the Martian surface.